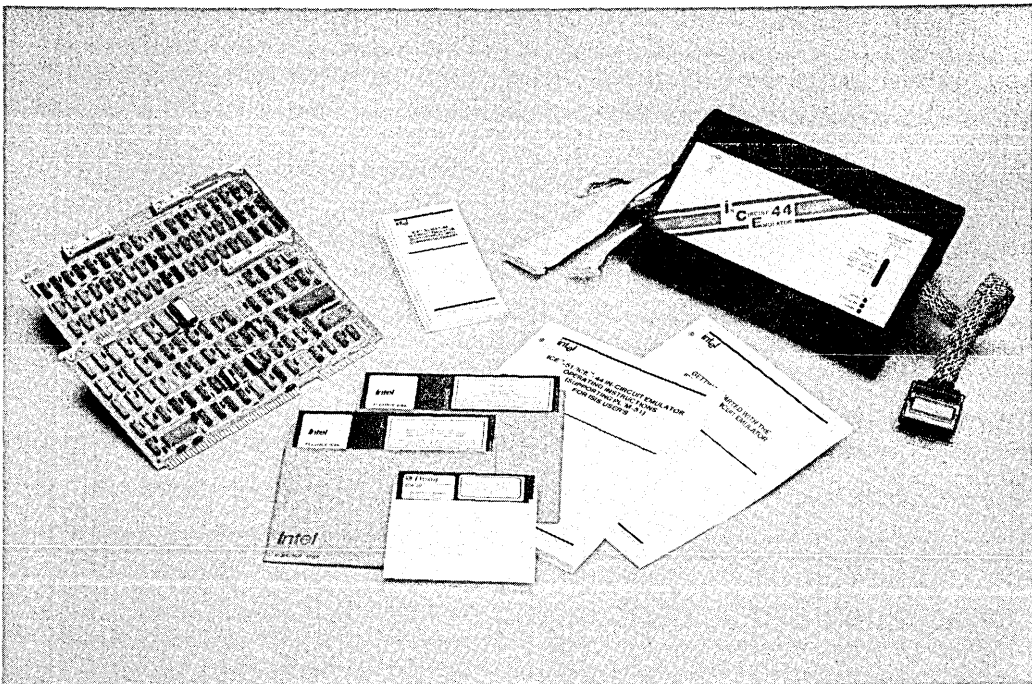




ICE™-44 MODULE 8044 IN-CIRCUIT EMULATOR

- Precise, full-speed, real-time emulation
- 8K bytes full-speed RAM
- User-specified breakpoints
- Execution trace
 - User-specified qualifier registers
 - Conditional trigger
 - Symbolic groupings and display
 - Instruction and frame modes
- Emulation timer
- Full symbolic debugging
- Single-line assembly and disassembly for program instruction changes
- Macro commands and conditional block constructs for automated debugging sessions

The ICE™-44 module resides in the Intel® Microcomputer Development System and interfaces to any user-designed 8044 system through a cable terminating in an 8044 emulator microprocessor and a pin-compatible plug. The emulator processor, together with 8K bytes of user RAM located in the ICE-44 buffer box, replaces the 8044 device in the user system while maintaining the 8044 electrical and timing characteristics. Powerful Intel® debugging functions are thus extended into the user system. Using the ICE-44 module, the designer can emulate the system's 8044 in real-time or single-step mode. Breakpoints allow the user to stop emulation on user-specified conditions, and a trace qualifier feature allows the conditional collection of 1000 frames of trace data. Using the single-line 8044 assembler, the user may alter program memory using 8044 assembler mnemonics and symbolic references, without leaving the emulator environment. Frequently used command sequences can be combined into compound commands and identified as macros with user-defined names.



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FUNCTIONAL DESCRIPTION

The ICE-44 emulator aids the design effort in several ways: software and hardware integration and debugging, symbolic debugging, and automated debugging and testing. The following sections describe these features.

Integrated Hardware and Software Development

The ICE-44 emulator allows hardware and software development to proceed interactively. This approach is more effective than the traditional method of independent hardware and software development followed by system integration. With the ICE-44 module, prototype hardware can be added to the system as it is designed. Software and hardware integration occurs while the product is being developed.

The ICE-44 emulator assists in four stages of development, as described in the following sections.

SOFTWARE DEBUGGING

The ICE-44 can be operated without being connected to the user's system and before any of the user's hardware is available. In this stage, ICE-44 debugging capabilities can be used with the Intellec text editor and the 8044 macro assembler to facilitate program development.

HARDWARE DEVELOPMENT

The ICE-44 module's precise emulation characteristics and full-speed program RAM make it a valuable tool for debugging hardware, including the time-critical synchronous data link control (SDLC) serial port, parallel port, and timer interfaces.

SYSTEM INTEGRATION

Software and hardware integration can begin when any functional element of the user system hardware is connected to the 8044 socket. As each section of the user's hardware is completed, it is added to the prototype. Thus, each section of the hardware and software is system tested in real-time operation as it becomes available.

SYSTEM TEST

When the user's prototype is complete, it is tested with the final version of the user system software. The ICE-44 module can then be used for real-time emulation of the 8044 to debug the system as a completed unit.

The final product verification test may be performed using the 8744 EPROM version of the 8044 microcomputer. Thus, the ICE-44 module provides the user with the ability to debug a prototype or production system at any stage in its development without introducing extraneous hardware or software test tools. Figure 1 shows an 8044 development configuration.

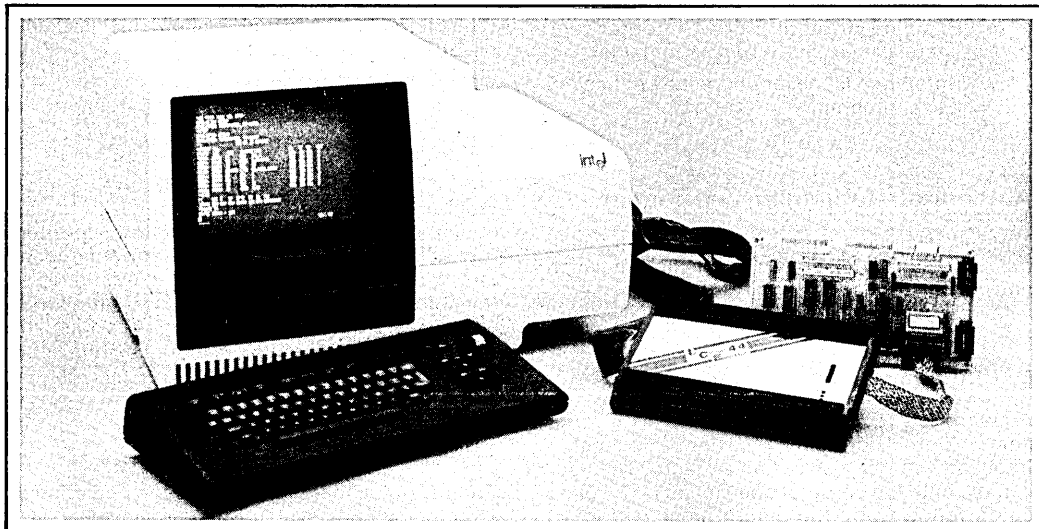


Figure 1. A Typical 8044 Development Configuration. The host system is an Intellec® Series IV. The ICE™-44 module is connected to a user prototype system.

Symbolic Debugging

The ICE-44 emulator permits the user to define and use symbolic (rather than absolute) references to program and data memory addresses; additional symbols are predefined by the ICE-44 software for referencing registers, flags, and input/output ports. Thus, the user need not recall or look up the addresses of key locations in a program as they change with each assembly, or become involved with machine code.

When a symbol is used for memory reference in an ICE-44 emulator command, the emulator supplies the corresponding location as stored in the ICE-44 emulator symbol table. This table is loaded with the symbol table produced by the assembler during application program assembly. The user can obtain the symbol table during software preparation simply by using the DEBUG switch in the ASM44 macro assembler. Furthermore, the user can interactively modify the emulator symbol table by adding new symbols, or changing or deleting old ones. This feature provides flexibility in debugging and minimizes the need to work with hexadecimal values.

Through symbolic references in combination with other features of the emulator, the user can easily do the following:

- Interpret the results of emulation activity collected during trace.
- Disassemble program memory to mnemonics, or assemble mnemonic instructions to executable code.
- Examine or modify 8044 internal registers, data memory, or port contents.
- Reference labels or addresses defined in a user program.

Automated Debugging and Testing

The following sections describe ways in which the user can automate some of the emulation and debug commands.

MACRO COMMANDS

A macro is a set of commands that is given a name. A group of commands that is executed frequently can be defined as a macro. The user can execute the group of commands by typing a colon followed by the macro name. Up to 10 parameters may be passed to a macro.

Macro commands can be defined at the beginning of a debug session and then used throughout a session. Macro definitions can be saved on disk for later use. The Intellec text editor may be used to edit the macro file.

The power of the development system can be applied to manufacturing testing as well as development, by writing test sequences as macros. The macros are stored on disk for use during system test.

COMPOUND COMMANDS

There are two kinds of compound commands. The IF command permits conditional execution of commands, and the COUNT and REPEAT commands allow repetitious execution of commands until certain conditions are met.

Compound commands may be nested any number of times, and they may be used in macro commands.

Example:

```
*DEFINE .I=0      ;Define symbol .I as 0
*COUNT 100H     ;Repeat the following
                  ;commands 100H times
.*IF .I AND 1 THEN ;Check if .I is odd
..*BYTE .I=.I     ;Fill the memory at location .I
                  ;to value .I
..*END
.*I=.I+1          ;Increment by 1
.*END             ;Command executes upon
                  ;carriage return after END
```

(The characters *, .*, and ..* shown in this example are system prompts that indicate the nesting level of compound commands.)

Operating Commands

The ICE-44 software is an Intellec RAM-based program that provides the user with easy-to-use commands for initiating emulation, defining breakpoints, controlling trace data collection, and displaying and controlling system parameters. ICE-44 commands are configured with a broad range of modifiers that provide the user with maximum flexibility in describing the operation to be performed.

EMULATION

The ICE-44 module can emulate the operation of a prototype 8044 system, at real-time speed (1.2 to 12 MHz) or in single-steps. Emulation

commands to the ICE-44 module control the process of setting up, running, and halting an emulation of the user's 8044-based system. Breakpoints and tracepoints enable the ICE-44 emulator to halt emulation and provide a detailed trace of execution in any part of the user's program. A summary of the emulation commands is shown in Table 1.

Breakpoints

The ICE-44 hardware includes two breakpoint registers that allow the user to halt emulation when specified conditions are met. The emulator continuously compares the values stored in the breakpoint registers with the status of specified address, opcode, operand, or port values, and halts emulation when this comparison is satisfied. When an instruction initiates a break, that instruction is executed completely before the break takes place. The ICE-44 emulator then regains control of the console and enters the interrogation mode. With the breakpoint feature, the user can specify an emulation break when the program:

- Executes an instruction at a specified address or within a range of addresses.
- Executes a particular opcode.
- Receives a specific signal on a port pin.
- Fetches a particular operand from the user program memory.
- Fetches an operand from a specific address in program memory.

Trace and Tracepoints

Tracing is used with both real-time and single-step emulation to record diagnostic information in the trace buffer as a program is executed. The information collected includes opcodes executed, port values, and memory addresses. The ICE-44 emulator collects up to 1000 frames of trace data.

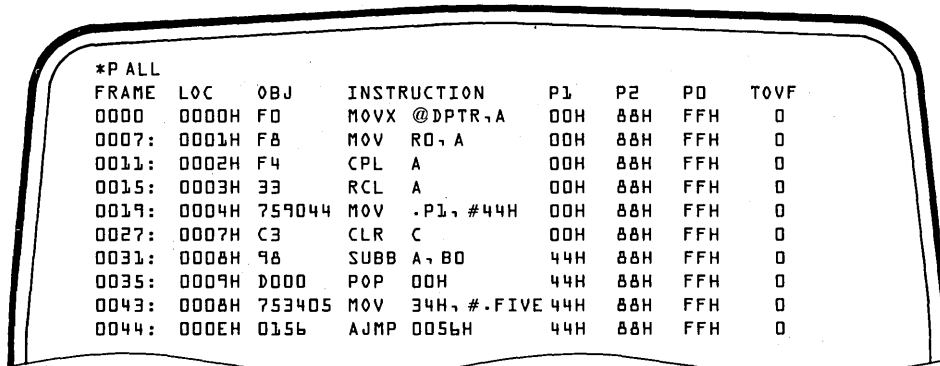
The trace data can be displayed as assembler instruction mnemonics, if desired, for analysis during interrogation or single-step mode. The trace-collection facility may be set to run conditionally or unconditionally. Two unique trace qualifier registers, specified in the same way as breakpoint registers, govern conditional trace activity. The qualifiers can be used to condition trace data collection to take place as follows:

- Under all conditions (forever).
- Only while the trace qualifier is satisfied.
- For the frames or instructions preceding the time when a trace qualifier is first satisfied (pre-triggered trace).
- For the frames or instructions after a trace qualifier is first satisfied (post-triggered trace).

Figure 2 shows an example of a trace display in instruction mode.

Table 1. Major Emulation Commands

Command	Description
GO	Begins real-time emulation and optionally specifies break conditions.
BR0, BR1, BR	Sets or displays either or both breakpoint registers used for stopping real-time emulation.
STEP	Performs single-step emulation.
QR0, QR1	Specifies match conditions for qualified trace.
TR	Specifies or displays trace-data collection conditions and optionally sets the qualifier register (QR0, QR1).
Synchronization line Commands	Sets and displays the status of synchronization line output or latched input. Used to synchronize the starting and stoping of real-time emulation or trace to occur with external events.



*P ALL	FRAME	LOC	OBJ	INSTRUCTION	P1	P2	PD	TOVF
	0000	0000H	F0	MOVX @DPTR, A	00H	88H	FFH	0
	0007:	0001H	F8	MOV R0, A	00H	88H	FFH	0
	0011:	0002H	F4	CPL A	00H	88H	FFH	0
	0015:	0003H	33	RCL A	00H	88H	FFH	0
	0019:	0004H	759044	MOV .P1, #44H	00H	88H	FFH	0
	0027:	0007H	C3	CLR C	00H	88H	FFH	0
	0031:	0008H	98	SUBB A, B0	44H	88H	FFH	0
	0035:	0009H	D000	POP 00H	44H	88H	FFH	0
	0043:	0008H	753405	MOV 34H, #.FIVE	44H	88H	FFH	0
	0044:	000EH	0156	AJMP 0056H	44H	88H	FFH	0

Figure 2. Sample Trace Display in Instruction Mode

INTERROGATION AND UTILITY COMMANDS

Interrogation and utility commands allow convenient access to detailed information about the user program and the state of the 8044 that is useful in debugging hardware and software. Changes can be made in memory and in the 8044 registers, flags, and port values.

Commands are also provided for various utility operations such as loading and saving program files, defining symbols, displaying trace data, controlling system synchronization, and returning control to ISIS. A summary of the basic interrogation and utility commands is shown in Table 2.

Table 2. Major Interrogation and Utility Commands

Command	Description
HELP	Displays help messages for ICE-44 emulator command-entry assistance.
LOAD	Loads the user object program (8044 code) into user program memory, and the user symbols into the ICE-44 emulator symbol table.
SAVE	Saves the ICE-44 emulator symbol table and the user object program in an ISIS hexadecimal file.
LIST	Copies all emulator console input and output to an ISIS file.
GO	Begins ICE-44 emulation.
EXIT	Terminates ICE-44 emulation operation and returns control to the ISIS operating system.
DEFINE	Defines the ICE-44 emulator symbol or macro.
REMOVE	Deletes user-defined symbols, modules, or macro names from the symbol table or macro table.
ASM	Assembles mnemonic instructions into user program memory.
DASM	Disassembles and displays user program memory contents.
Change/Display Commands	Changes or displays the value of a symbolic reference in the ICE-44 emulator symbol table, the contents of keyword references (including registers, I/O ports, and status flags), or the memory references.
EVALUATE	Evaluates an expression and displays the resulting value.
MACRO	Displays an ICE-44 macro or macros.
INTERRUPT	Displays serial, external, or timer-interrupt register settings.
SECONDS	Displays the contents of the emulation timer in microseconds.
Trace Commands	Positions the trace buffer pointer and selects the format for the trace display.
PRINT	Displays the trace data pointed to by the trace buffer pointer.

Single-line Assembler/Disassembler

The single-line assembler/disassembler (ASM and DASM commands) is a time-saving emulator feature that permits the designer to examine and alter program memory using assembly language mnemonics, without leaving the emulator environment or requiring time-consuming program reassembly. When assembling new mnemonic instructions into program memory, previously defined symbolic references (from the original program assembly, or subsequently defined during the emulation session) may be used in the instruction operand field. The emulator will supply the absolute address or data values as stored in the emulator symbol table. These features eliminate user time spent translating to and from machine code and searching for absolute addresses, with a corresponding reduction in transcription errors.

Help

The HELP file allows the user to display ICE-44 command syntax information at the Intellec console. Typing HELP displays a listing of all

items for which help messages are available; typing HELP <item> displays relevant information about the item requested, including typical usage examples. See Figures 3 and 4 for screen displays of a HELP menu and a HELP <item> menu.

Emulation Accuracy

The speed and interface demands of a high-performance single-chip microcomputer require extremely accurate emulation, including full-speed, real-time operation with the full function of the microcomputer. The ICE-44 emulator achieves accurate emulation with an 8044 bond-out chip, a special configuration of the 8044 microcomputer, as its emulation processor.

Each of the 40 pins on the user plug is connected directly to the corresponding 8044 pin on the bond-out chip. Thus, the user system sees the emulator as an 8044 microcomputer at the 8044 socket. The resulting characteristics provide extremely accurate emulation of the

*HELP

Help is available for the following items. Type HELP followed by the item name. The help items cannot be abbreviated. (for more information, type HELP HELP or HELP INFO.)

Emulation: Trace Collection:
GO GR SYD TR QR QRD QR1 SYL
BR BRD BR1
STEP Trace Display:
 TRACE MOVE PRINT
 OLDEST NEWEST

Change/Display/Define/Remove:
<CHANGE> REMOVE CBYTE RBIT
<DISPLAY> SYMBOL DBYTE DASH
REGISTER RESET PBYTE ASM
SECONDS WRITE RBYTE MAP
DEFINE STACK XBYTE SY

Macro: Compound
DEFINE DIR Commands:
DISABLE ENABLE COUNT
INCLUDE PUT IF
<MACRO*DISPLAY> REPEAT
<MACRO*INVOCATION>

Misc: <address>
BASE <CPU#keyword>
DISABLE <expr>
ENABLE <ICE44#keyword>
ERROR <identifier>
EVALUATE <instruction>
HELP <masked#constant>
INFO <match#cond>
<LIGHTS> <numeric#ref>
LIST <partition>
LOAD <string>
SAVE <string#constant>
SUFFIX <symbolic#ref>
SYMBOLIC <system#symbolic>
 <trace#reference>
 <unlimited#match#cond>
 <user#symbols>

Figure 3. Menu Display for HELP

***HELP IF**

IF - The conditional command allows conditional execution of one or more commands based on the values of boolean conditions.

```
IF <expr> [THEN] <cr>    <true#list>: :=[<command> <cr>]@
<true#list>              <false#list>: :=[<command> <cr>]@
[OR IF <expr> <cr>      <command>: :=An ICE-44 command.
<true#list>]@
[ELSE <cr>
<false#list>]
END
```

The <expr>s are evaluated in order as 16-bit unsigned integers. If one is reached whose value has low-order bit 1 (TRUE), all commands in the <true#list> following that <expr> are then executed and all commands in the other <true#list>s and in the <false#list> are skipped. If all <expr>s have value with low-order bit 0 (FALSE), then all commands in all <true#list>s are skipped and, if ELSE is present, all commands in the <false#list> are executed.

```
(EX: IF .LOOP=5 THEN
STEP
ELSE
GO
END)
```

Figure 4. Menu Display for HELP IF

8044, including speed, timing characteristics, load and drive values, and crystal operation. The emulator may draw more power from the user system than a standard 8044 family device (see Electrical Characteristics).

Additional bond-out pins provide the emulator box with signals such as internal address, data, clock, and control lines. These signals let static RAM in the buffer box substitute for on-chip program ROM, EPROM, or user supplied external program memory. The 8K bytes of full-speed RAM in the buffer box can be mapped in 4K blocks to anywhere within the 64K program memory space of the 8044. The bond-out chip also gives the emulator "backdoor" access to internal chip operation, so that the emulator can break and trace execution without interfering with the values on the user-system pins.

SPECIFICATIONS

ICE™-44 Operating Requirements

Intellec Model 800, Series II/III, or Series IV development system (64K RAM required)

System Console

One disk drive, single-density or double-density

Intellec disk operating system (single or double density) ISIS v. 3.4 or later

Equipment Supplied

- Printed circuit boards(2)
- Emulation buffer-box, Intellec interface cables, and user-interface cable with an 8044 emulation processor
- Dual auxiliary connector kit for the Model 800, Series II/III, and Series IV development systems
- Crystal power accessory
- Literature kit
 - ICE-44 operating instructions manual
 - ICE-44 command dictionary
 - ICE-44 user's guide
- Disk-based ICE-44 software (5 1/4 inch and 8 inch, single and double density)

Emulation Clock

User's system clock (1.2 to 12MHz) or ICE-44 crystal power assembly (12MHz)

Environmental Characteristics

Operating Temperature: 0° to 40° C

Operating Humidity: Up to 95% relative humidity without condensation

Physical Characteristics
Printed Circuit Boards

Width: 12.00 in. (30.48cm)
Height: 6.75 in. (17.15 cm)
Depth: 0.50 in. (1.27 cm)

Buffer Box

Width: 8.00 in. (20.32 cm)
Length: 12.00 in. (30.48 cm)
Depth: 1.75 in. (4.44cm)
Weight: 4.0 lb (1.81 kg)

Interface Cables

Host-emulator interface cable length: 48 in. (121.92 cm)
Emulator-user-system interface cable length: 12.00 in. (30.48 cm)

Electrical Characteristics
DC Power Requirements (from the Intellect system):

$V_{CC} = +5V, +5\%, -2.5\%$
 $I_{CC} = 13.2A \text{ max; } 11.0A \text{ typical}$
 $V_{DD} = +12V, +5\%$
 $I_{DD} = 0.1 A \text{ max; } 0.05A \text{ typical}$
 $V_{BB} = -10V, +5\%$
 $I_{BB} = 0.05A \text{ max; } 0.01A \text{ typical}$

User Plug Characteristics at the 8044 Socket:

Same as an 8044 or 8744, except that the user system will see an added load of 25 pf capacitance and 50 uA leakage from the ICE-44 emulator user plug at ports 0, 1, and 2.

ORDERING INFORMATION

Part Number	Description
ICE-44	8044 microcontroller in-circuit emulator, cable assembly, and interactive disk software